

Two Species of Notodelphyid Copepoda (Cyclopoida) Associated with Solitary Ascidians (Tunicata)

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ABSTRACT

Notodelphyid copepods taken from Ascidians, *Ascidia samea* (Oka) and *Ascidia* sp. which had been collected in the East sea and the Korea Strait are reported. These copepods are *Lonchidiopsis hartmeyeri* Vanhöffen, 1917 and *Pachypygus curvatus* Ooishi 1961, and are redescribed as new records to the Korean fauna.

Key words: Notodelphyid copepods, Redescription, Ascidians, Korea

INTRODUCTION

The Notodelphyidae is one of the main families of cyclopoid copepods associated with ascidians, therefore, it is called ascidicole cyclopoid. The concepts of the Notodelphyidae is revised by Illig (1958). The wide branchial sac of the ascidians affords a safe place of ascidicol cyclopoids to live in, and the respiratory stream of the ascidians provides sufficient food (Stock, 1950). Most notodelphyids lead a symbiotic existence in the branchial sac of solitary ascidians, but some are parasites encysted in the tunic or ventral blood vessel, or in the matrix of compound ascidians (Jones, 1974). In solitary ascidians, the branchial sac, esophagus, stomach and intestine are usually favored as accommodations for these copepods (Ooishi, 1991).

Though the total number of Notodelphyidae in the world is not exactly known, it is estimated that the number is slightly over one hundred species (Stock, 1967). The taxonomic study on Korean copepods associated with ascidians was attempted recently by the present authors who reported two species (Seo and Lee, 1995a, b).

DESCRIPTIONS

Order Cyclopoida Burmeister, 1834 겹(劍)물벼룩 목

Family Notodelphyidae Dana, 1853 노트델피스 과(新淸)

***Lonchidiopsis hartmeyeri* Vanhöffen, 1917** 하르트메예리긴배해초속살이(新淸) (Figs. 1-6)

Lonchidiopsis hartmeyeri Vanhöffen, 1917, p. 224, figs. 1-7; Schellenberg, 1922, p. 259; Ooishi and Illg, 1986, p. 45, figs. 1-8.

Material Examined. 16 ♀ ♀ from *Ascidia samea* (Oka), Imwŏn in the East sea, 27 Dec. 1986; 3 ♀ ♀, 3 ♂ ♂ from *Ascidia* sp., Tongyŏng in the Korea Strait, 15 Feb. 1995.

Female. Body (Fig. 1A, B) 2.88 mm (from tip of cephalosome to end of caudal ramus), strongly depressed, without dorsal curvature. Body divided into cephalosome, metasome and urosome, their proportional lengths about 1.3 : 7 : 1. Anterior cephalosome posteroventrally protruded into enlarged and rounded rostrum and laterally widened into pleural epimeral areas, forming a wing-like cephalic shield. Rostrum with rostral protrusion on anteroventral surface between antennules. Appendages of cephalosome consist of a pairs of antennule, antenna, mandible, maxillule, maxilla and maxilliped. Metasome 4-segmented; their proportional lengths about 1 : 1.7 : 2 : 25. Fourth segment elongated and with legs 4 and 5. Third segment posteriorly wide and protrudes into a semicircle on dorsal margin toward fourth segment, which consist of a complex of fused to anatomically fourth and fifth segments and encloses brood pouch. Leg 4 placed on the anterior end of complex close to leg 3 whereas reduced leg 5 implanted posteroventrally near posterior margin of complex. Urosome weakly 3-segmented and bearing small caudal rami with short setae. First segment with insemination pore on anterior margin of segment midventrally.

Antennule (Fig. 1D) 8-segmented, complicated segmentation, with long (ls) and short (ss) setae. First segment strongly enlarged. Second segment slightly tapers, ventrally expanded, length of dorsal margin shorter than ventral one. Third segment shorter than dorsal margin of second one. From fourth to eighth segments narrower than basal 3 segments and strongly curved ventrally at fourth segment. From fifth to eighth segments longer than wide. Setal formula: 2 ls, 5 ls+13 ss, 5 ss, 2 ss, 3 ss, 3 ss, 2 ss, 10 ss.

Antenna (Fig. 2E, F) consists of 3 segments, proportional lengths about 1 : 2.2 : 1.7, measured on anterior margin. Proximal 2 segments unarmed. Distal segment with 2 short setae on outer distal margin, 1 claw with 3 short setae on its base.

Labrum broad, ventrally protruded, with 2 groups of hairs on anterior and posterior margins.

Mandible (Fig. 2A) well-developed, consists of bimerous protopodite and rami. Masticatory lamella of coxa with 5 teeth, of which distal one largest, sharply, finely serrated edge, with 2 tiny setae proximally. Basipodite with 1 seta on medial margin. Endopod weakly 2-segmented; proximal segment with 4 (3 short and 1 long) medial setae; distal segment with 9 setae (7 long and 2 short). Exopod wider than long, with 5 graduated long plumose setae. Paragnath located on between mandible and maxillule, consists of a simple membranous protrusion from body surface, with short hairs on mediobasal corner.

Maxillule (Fig. 2B) consists of bimerous protopodite and unimerous rami. Major endite with 10 setae

on median margin and 1 setiform on distal margin of secondary endite. Epipodite with 1 long and 1 short seta. Basipodite with 4 medial setae. Endopod with 5 graduated setae on medial and distal margins. Exopod with 4 long setae on distal margin.

Maxilla (Fig. 2C, D) consists of 3-segmented. Basal segment about 4 times as long as remaining segments combined together and with long (ls) and short (ss) setae on 4 endites; 4 ls, 1 ls, 2 ls, 2 ls+1 ss. Second segment produced 1 long stout claw with a row of fine setules on posterior margin and anterior base of claw with 1 long seta. Third segment small, with 4 simple setae and 1 short plumose seta on rounded apical margin.

Maxilliped (Fig. 2E) relatively small, 2-segmented, their proportional lengths about 2 : 1. Proximal segment with 5 setae on medial margin. Second segment with 3 setae on distal and proximal margins.

Legs 1-4 (Fig. 3A-D) consist of bimerous protopodite and rami. Coxopodite unarmed. Leg 1 (Fig. 3A), basipodite with 1 long outer lateral seta and 1 inner apical spine. Basal segment of exopod longer than distal one. Exopod longer than endopod. Leg 2 (Fig. 3C), protopodite narrower than that of leg 1, rami more developed in size, basipodite with 1 short lateral seta, spines of second endopodal segment elongated. Leg 4, protopodite and rami more slender than those of legs 1-3, rami with only spines. Armature formula of legs 1-4 as follows (Roman numerals indicate spine, and Arabic ones, setae):

Leg 1	Prp 0-0; 1-I	Enp 0-1; I-5
		Exp I-1; V-0
Leg 2	Prp 0-0; 1-0	Enp 0-1; V-0
		Exp I-1; V-0
Leg 3	Prp 0-0; 1-0	Enp 0-1; V-0
		Exp I-1; IV-0
Leg 4	Prp 0-0; 1-0	Enp 0-0; III-0
		Exp 0-I; IV-0

Leg 5 (Fig. 1G) small, cylindrical, weakly 2-segmented, ramus with 1 short subdistal and 1 long distal seta on distal segment and lateral base of ramus with 1 seta.

Caudal ramus (Fig. 1H) about 3.5 times as long as wide, as long as anal segment, with 1 medial and 1 distal seta on lateral margin, and 4 setae on apical margin.

Male. Body (Fig. 4A, B) length 1.34 mm (from tip of cephalosome to end of caudal ramus), smaller than female. Cephalosome laterally prolonged, forming leaf-like pleural areas which recurve ventrally. Rostrum small, subtriangular, with tiny finger-like rostral protrusion at tip. Antennule anteriorly protruded from both sides of rostrum. Metasome 4-segmented, gradually elongated, their proportional lengths about 1 : 1.5 : 1.5 : 2.2, with each a pair of swimming legs. Urosome 6-segmented; first and second segments wider than long, with leg 5 and leg 6, respectively. Third to sixth segments longer than wide. Construction between metasome and urosome no marked.

Antennule (Fig. 4C) more slender than that of female, gradually tapered from proximal to distal, 8-segmented, with long (ls) and short (ss) setae. Second segment incomplete divided into 2-segmented. Setal formula: 2 ls, 5 ls+11 ss, 4 ss, 2 ss, 3 ss, 2 ss, 2 ss, 9 ss.

Antenna (Fig. 4G) distinctively modified, with chelate, 3-segmented. First segment anteriorly depressed. Second segment broad, anterodistally extended. Third segment narrow, with 2 short setae on anterodistal margin. Claw with 3 proximal setae.

Mandible (Fig. 5A), maxillule (Fig. 5B), maxilla (Fig. 5D) and maxilliped (Fig. 5C) same as those of female in structure and armature.

Legs 1-4 (Fig. 6A-D) slender, and longer than those of female, armature and structure same as those of female. Armature formula of legs 1-4 as follows (Roman numerals indicate spine, and Arabic ones, setae):

Leg 1	Prp 0-0; 1-1	Enp 0-1; 1-5
		Exp 1-0; V-0
Leg 2	Prp 0-0; 1-0	Enp 0-1; V-0
		Exp 1-1; V-0
Leg 3	Prp 0-0; 1-0	Enp 0-1; V-0
		Exp 1-1; IV-0
Leg 4	Prp 0-0; 1-0	Enp 0-0; 0-III
		Exp 1-0; III-1

Leg 5 (Fig. 4F) same as female in structure and armature. Leg 6 (Fig. 4D) located on second urosomal somite, with 2 short naked setae on distal margin of flap-like. Caudal ramus (Fig. 4E) same as in female in setal number, but length of setae long.

Distribution. Australia and Japan.

Remarks. The genus *Lonchidiopsis* comprises three species, of which *L. hartmeyeri* Vanhöffen, 1917 was found the branchial sac of members of the genus *Ascidia* was reported by Vanhöffen (1917) from Australia and Ooishi and Ilg (1986) from Japan, respectively. Although there are minute morphological and ecological differences between Australian and Japanese specimens of *L. hartmeyeri*, our specimens are similar to Japanese.

L. tripes was reported by Stock (1967) from *Ascidia nigra* collected in the Red Sea (off Landing Bay, Dahalk Archipelago, Ethiopia). It is distinguishable from the other two known species, *L. hartmeyeri*, and *L. setosus* by the fact that it has the relatively much reduced leg 4. *L. setosus* was reported by Jones and Moreno (1981) from *Rodosoma turcicum* collected in the Gulf of Cariaco, Venezuela. The fifth pedigerous segment of *L. tripes* and *L. setosus* is not fused to the broodsack, whereas it is fused to the broodsack of *L. hartmeyeri*.

***Pachypygus curvatus* Ooishi, 1961 굽은똥보해초속살이(신칭) (Figs. 7-9)**

Pachypygus curvatus Ooishi, 1961, p. 87, figs. 1.2.

Material Examined. 3 ♀ ♀ from *Ascidia* sp. Tongyong in the Korea Strait, 15 Feb. 1995; 5 ♀ ♀ from *Ascidia* sp. Tongyong in the Korea Strait, 20 Feb. 1995; 3 ♀ ♀ from *Ascidia* sp. Kojedo in the Korea Strait, 26 Jun. 1995.

Female. Body (Fig. 7A) length 5.54 mm (from tip of cephalosome to end of caudal ramus), large, compressed and robust. Integument heavily sclerotized, covered by spinules. Cephalosome large, rounded ventrally and posteriorly. Metasome 4-segmented: fourth segment forming a large brood

pouch. Urosome 6-segmented. Rostrum large, long, triangular, twice as long as base.

Antennule (Fig. 7D, E) 9-segmented, two proximal segments elongate and expanded, remaining segments short and slender. Setal formula: 3, 16, 4, 9, 9, 3, 3, 2, 8 + 1 aesthete. Two of 3 setae of first segment very long.

Antenna (Fig. 7B, C) distinctly 3-segmented, proportional lengths of segments 1.5 : 1 : 1. First segment with 2 tiny setae on outer distal corner. Second segment with 1 tiny seta on inner subdistal margin. Third segment with 1 proximal tiny seta, a group of setae consisted of 3 setae on subdistal margin, distally 3 setae and 1 stout claw.

Mandible (Fig. 8A) consists of 2-segmented protopodite, 2-segmented endopod and 1-segmented exopod. Masticatory lamella of coxa divided into 5 teeth, fruncate plate and 2 proximal setules. Basipodite with 1 long seta on distal margin, a group of denticulate on inner distal margin. Basal segment of endopod with 4 setae on lateral margin, terminal segment with 10 setae on lateral and apical margins. Exopod with 5 distal and apical setae.

Maxillule (Fig. 8B) consists of 2-segmented protopodite, 2-segmented endopod and 1-segmented exopod. Coxopodite with 1 long, stout seta and 1 short seta on distal angle. Major endite large, with 10 setae on median margin. Second endite with 1 setiform projection. Basipodite with 4 setae. Endopod with 4 setae on lateral margin of basal segment, 3 setae on apical margin of distal segment. Exopod rectangular, with 4 long marginal setae.

Maxilla (Fig. 8D) 5-segmented, broadened at base, slender toward tip. Basal segment with 4 setiferous endites: first endite with 4 setae; second one with 1 seta; third one 2 setae and fourth one 2 setae and 1 tiny setule. Second segment with 1 heavy claw and 2 slender setae on base of claw. Third and fourth segments with 1 long seta on distal corner, respectively. Fifth segment small, with 3 slender subequal apical setae and 1 proximal seta.

Maxilliped (Fig. 8G) consists of 3 setiferous segments. Basal segment with 9 setae on median margin. Second segment with 1 long seta on middle of median margin. Third segment shortest, with 3 apical setae and 1 proximal seta.

Leg 1 (Fig. 9A) consists of 2-segmented protopodite and 3-segmented rami. Protopodites of both sides connected with each other by well-developed intercoxal plate. Coxopodite with 1 long seta on medio-distal corner of inner margin. Basipodite with 1 lateral seta on outer margin and 1 stout median spine on inner margin. Two basal segments of endopod with 1 long median plumose seta, respectively. Terminal segment with 3 median, 2 apical and lateral plumose setae. First to third segments with delicate hairs on lateral margin. Two basal segments of exopod with 1 median seta and 1 lateral spine, respectively. Terminal segment with 4 inner setae and 4 outer spines.

Leg 2 (Fig. 9B) consists of 2-segmented protopodite and 3-segmented rami. Coxopodite with 1 long seta at medio-distal corner. Basipodite with 1 short slender lateral seta. Both rami highly chitinated. First segment of endopod with 1 seta on outer distal margin; second segment with 2 long setae; third segment with 3 median, 2 apical and 1 lateral seta. Exopod modified, longer than endopod. First segment longer than rest segments, with 1 outer distal spine and 1 inner median seta. Second segment with 1 outer distal spine and 1 inner distal seta. Third segment with 4 outer spines and 5 inner setae. Leg 3 (Fig. 9C) similar to leg 2, but exopod as long as endopod. Setal formula as in leg

2. Leg 4 (Fig. 8E, F) with 2-segmented protopodite and 3-segmented rami. Rami distinctly unequal structure. Coxopodite with 1 seta on medio-distal corner. Basipodite with 1 short slender lateral seta. Exopod longer than endopod; first segment of endopod with 1 short seta; second segment with 2 long setae; third segment with 2 median, 2 apical and 1 lateral seta. First to third segments with hairs on lateral margin. First segment of exopod longer than remaining segments, with 1 lateral spine on distal corner and several transverse rows of denticles on lateral margin and inner face. Second segment with 1 lateral spine on distal corner margin and 1 short seta on inner margin. Third segment with 2 lateral and 1 apical spine, 5 setae on inner margin. Leg 5 (Fig. 9D) 2-segmented; basal segment longer than wide, with 1 outer distal seta, a row of spinules on inner distal margin and spinules on inner face; second segment slightly shorter than basal segment, with 7 rows of spinules on median inner margin, with 2 terminal setae.

Caudal ramus (Fig. 9E, F) short, stout, with 1 seta on middle of inner face and 3 terminal spines and 1 terminal tiny seta.

Male. Unknown.

Distribution. Japan.

Remarks. The present species is characterized by large size and a strongly sclerotized integument. It can be easily distinguished from *P. gibber* (Thorell, 1859) and *P. macer* Illg, 1958 by the modified exopod of legs 2-4, especially of leg 4. The present species is very close to the *P. australis* (see Gotto, 1975). Two species are similar to each other in the several morphological characteristics except for the length and form of antenna, the form of the basal segment of leg 5 and the number of lateral spines of the third exopodal segment of leg 4. But *P. curvatus* is distinguishable from *P. australis* by the following characteristics: the former has two lateral spines on the third segment of leg 4 and unlike in the former species, in the latter the basal segment of leg 5 has a triangular protuberance on the outer distal corner.

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단체 해초류(피낭류)에 공생하는 요각류 2종

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요 약

동해와 남해에 서식하는 단체 해초류(시메아대추멍게와 대추멍게류)의 체강내에서 요각류 2종이 채집되었다. 이들은 *Lonchidiopsis hartmeyeri* Vanhöffen, 1917 과 *Pachypygus curvatus* Oishi, 1961이며, 한국미기록종으로서 재기재하여 보고한다.



Fig. 1. *Lonchidiopsis hartmeyeri* Vanhöffen, female. A, habitus, dorsal; B, habitus, ventral; C, mouth part, ventral; D, antennule; E, antenna; F, terminal portion of antenna; G, leg 5; H, caudal ramus. Scales: A, B = 0.5 mm; C = 0.01 mm; D, E = 0.05 mm; G = 0.02 mm; F, H = 0.03 mm.

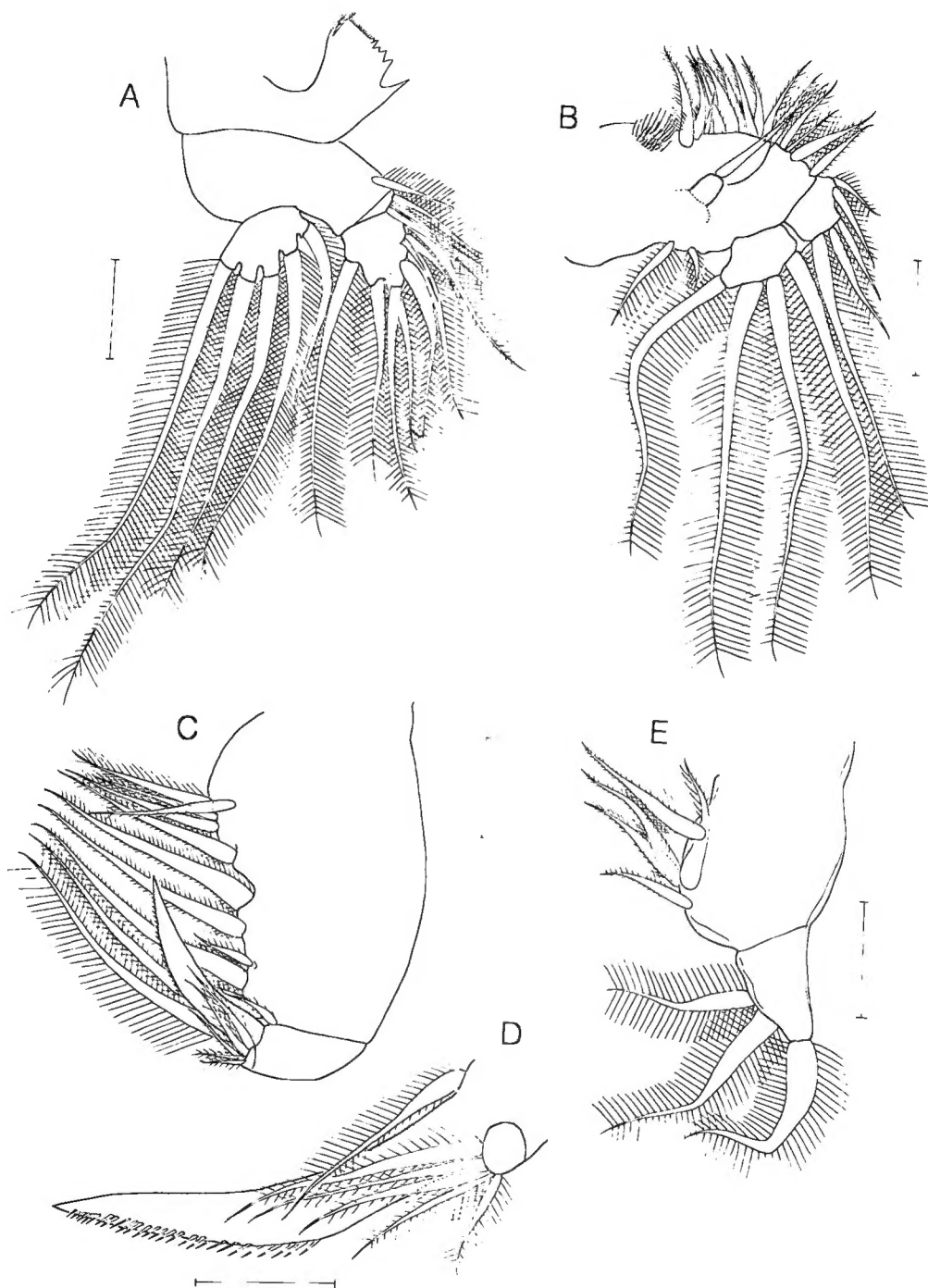


Fig. 2. *Lonchidiopsis hartmeyeri* Vanhöffen, female. A, mandible; B, maxillule; C, maxilla; D, terminal portion of maxilla; E, maxilliped. Scales: A, B = 0.05 mm; C, E = 0.03 mm; D = 0.02 mm.

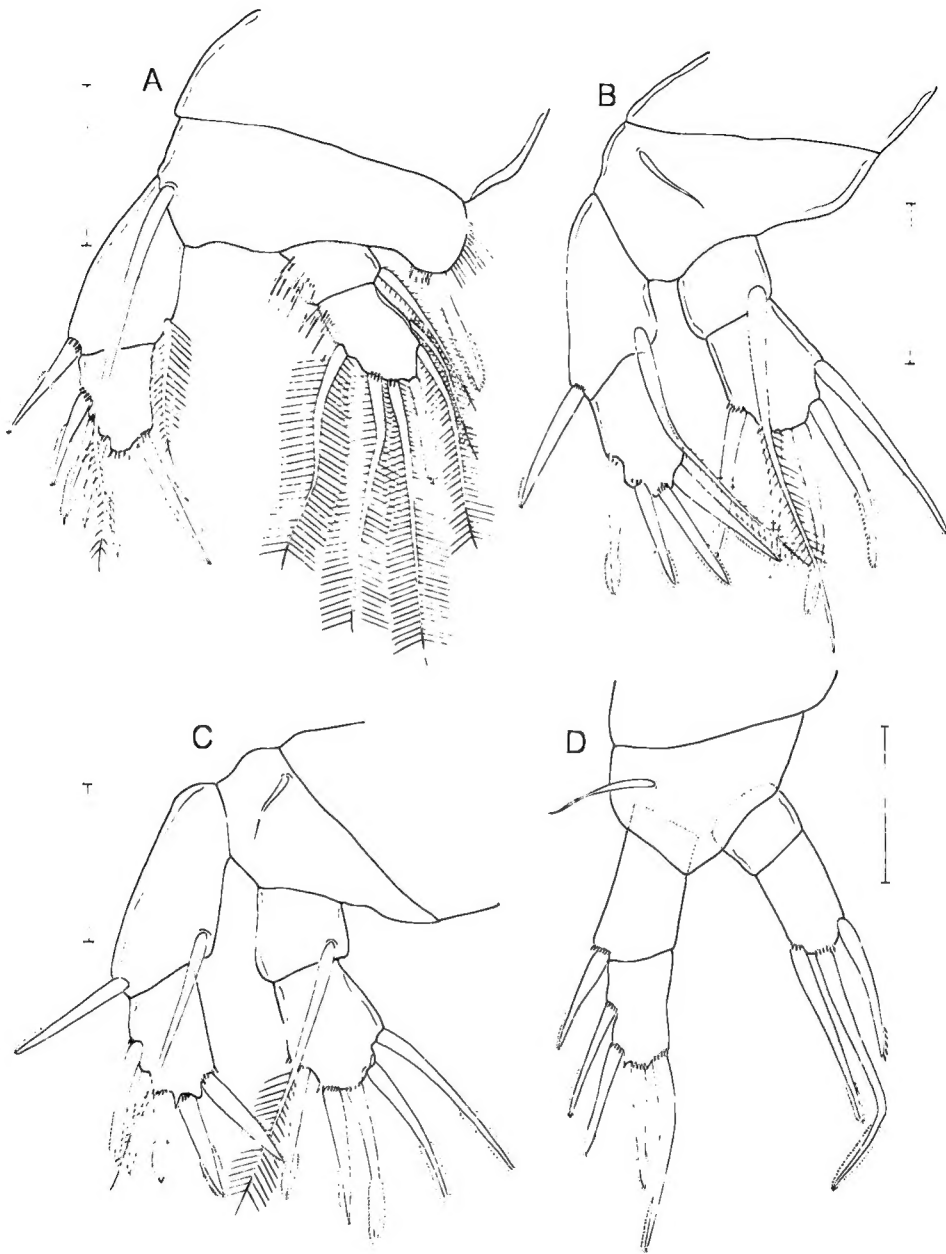


Fig. 3. *Lonchidiopsis hartmeyeri* Vanhöffen, female. A, leg 1; B, leg 3; C, leg 2; D, leg 4. Scale: A-D = 0.05 mm.

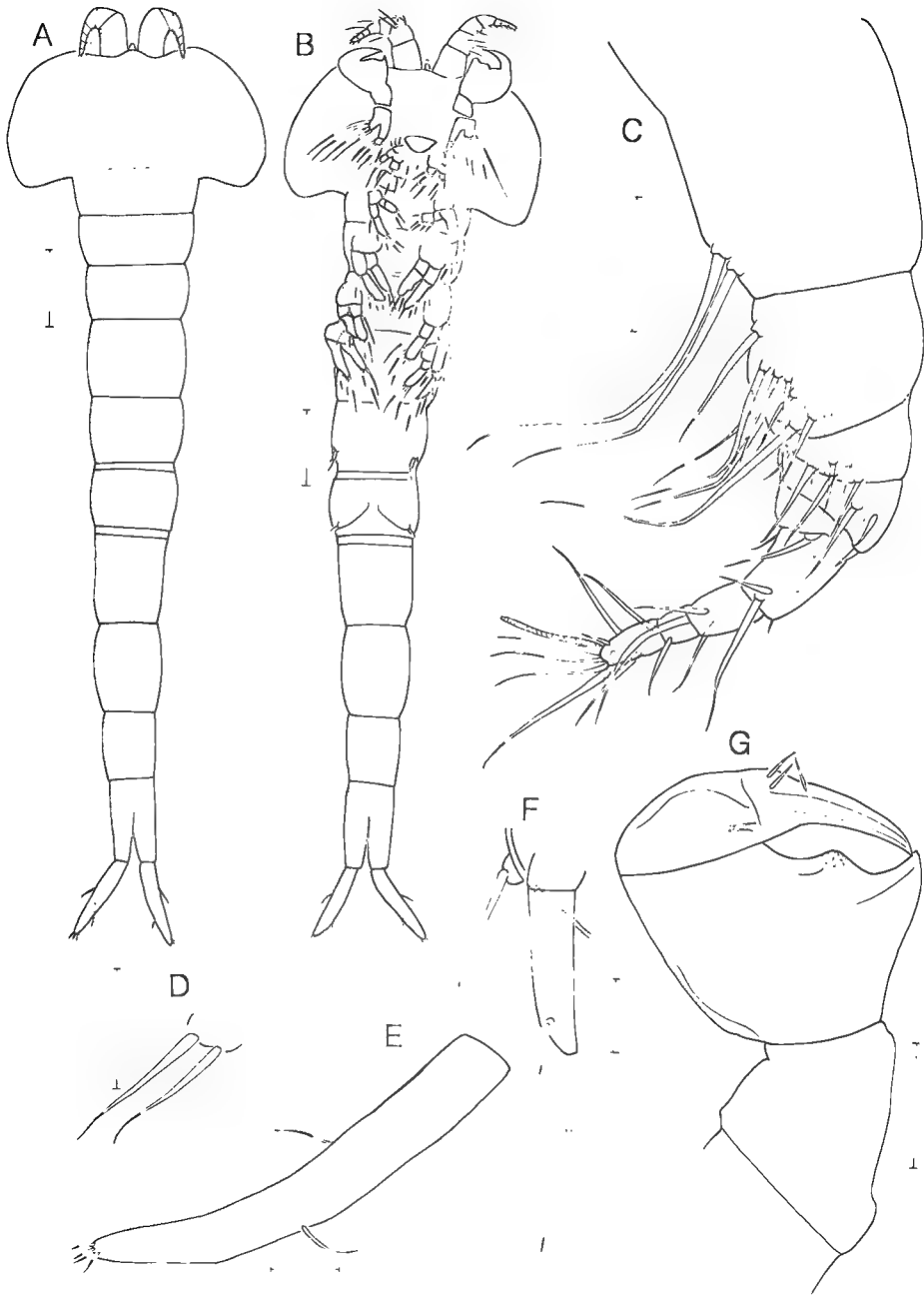


Fig. 4. *Lonchidiopsis hartmeyeri* Vanhöffen, male. A, habitus, dorsal; B, habitus, ventral; C, antennule; D, leg 5; E, antenna; F, leg 6; G, caudal ramus. Scales: A, B = 0.1 mm; C, G = 0.03 mm; D, F = 0.01 mm; E = 0.25 mm.

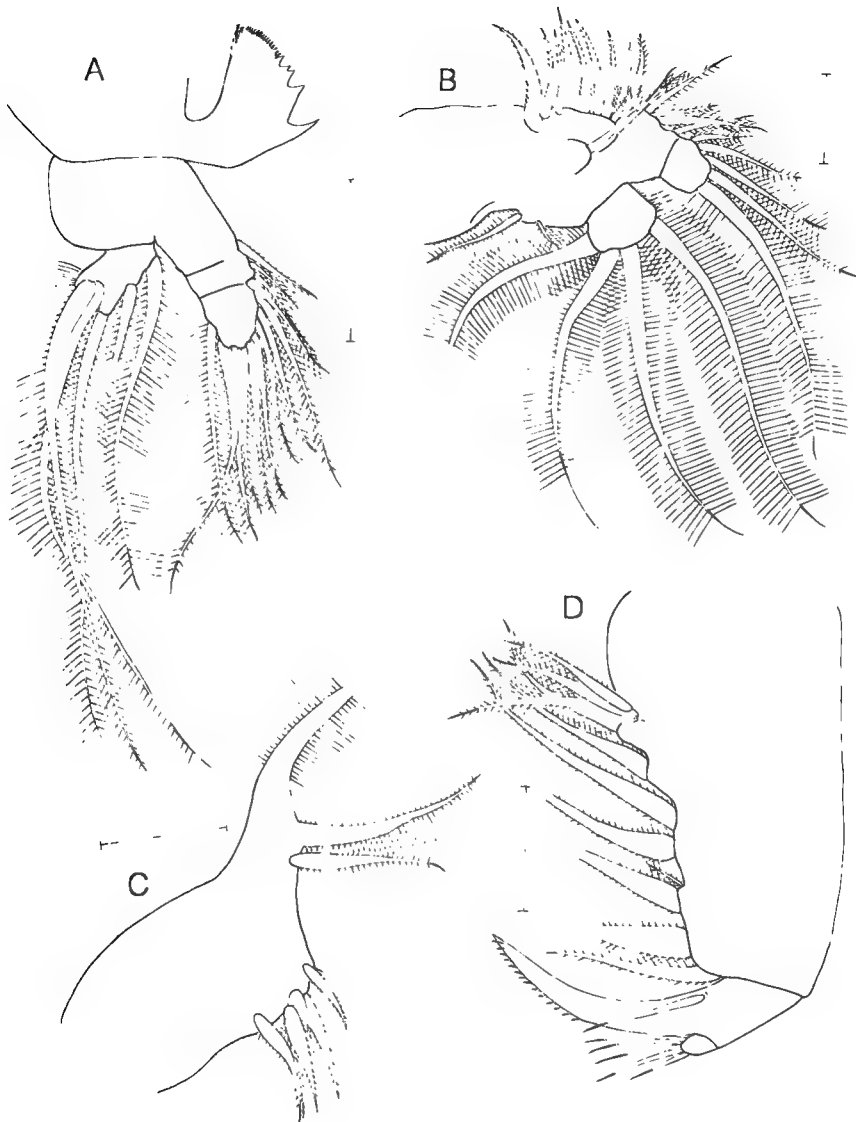


Fig. 5. *Lonchidiopsis hartmeyeri* Vanhöffen, male. A, mandible; B, maxillule; C, maxilliped; D, maxilla. Scales: A = 0.03 mm; B - D = 0.02 mm.

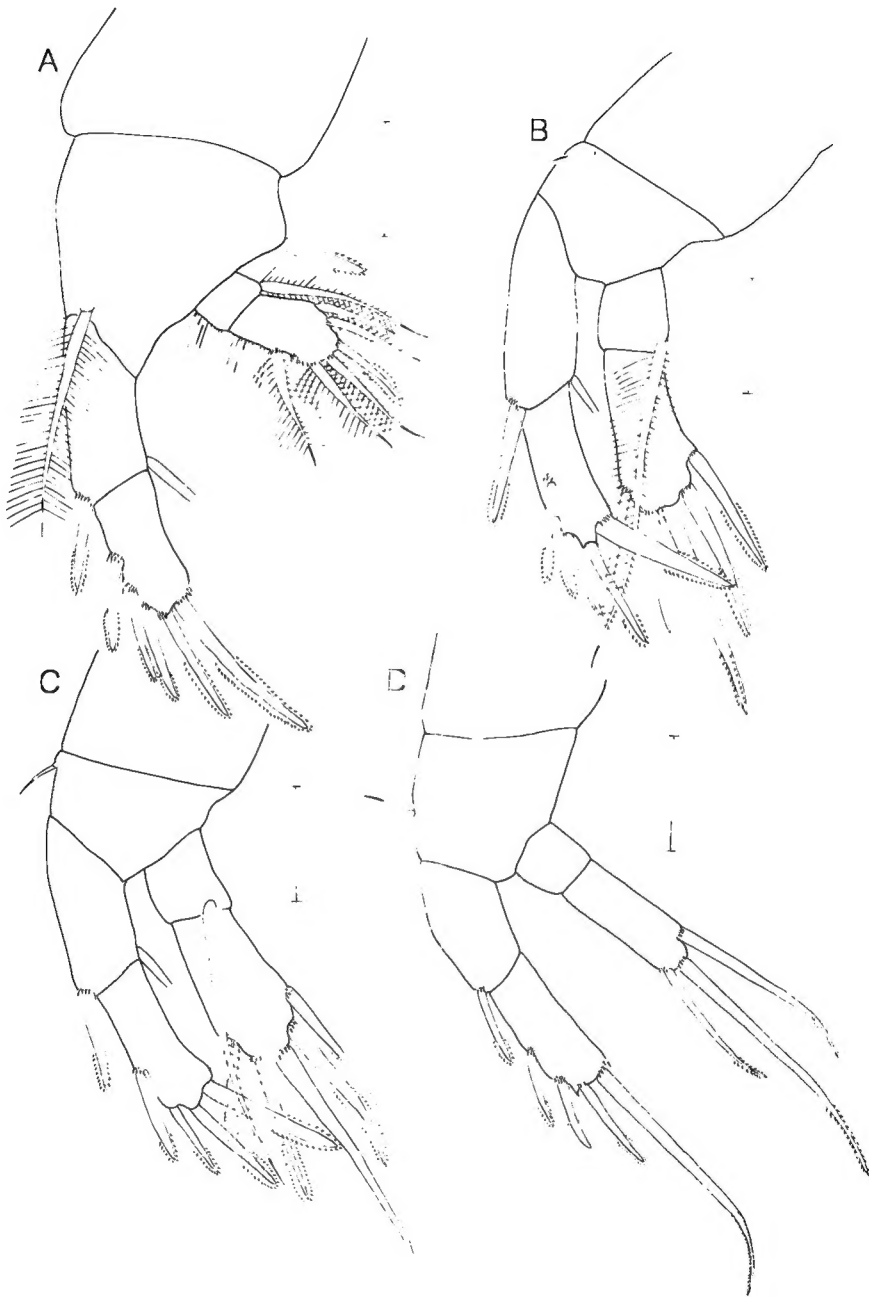


Fig. 6. *Lonchidiopsis hartmeyeri* Vanhöffen, ma'e. A, leg 1; B, leg 2; C, leg 3; D, leg 4. Scale: A - D = 0.03 mm.



Fig. 7. *Pachypygus curvatus* Ooishi, female. A, habitus, lateral; B, terminal portion of antenna; C, antenna; D, antennule; E, distal segments of antennule; F, rostrum, ventral. Scales: A = 0.5 mm; B = 0.25 mm; C, F = 0.1 mm; D, E = 0.05 mm.

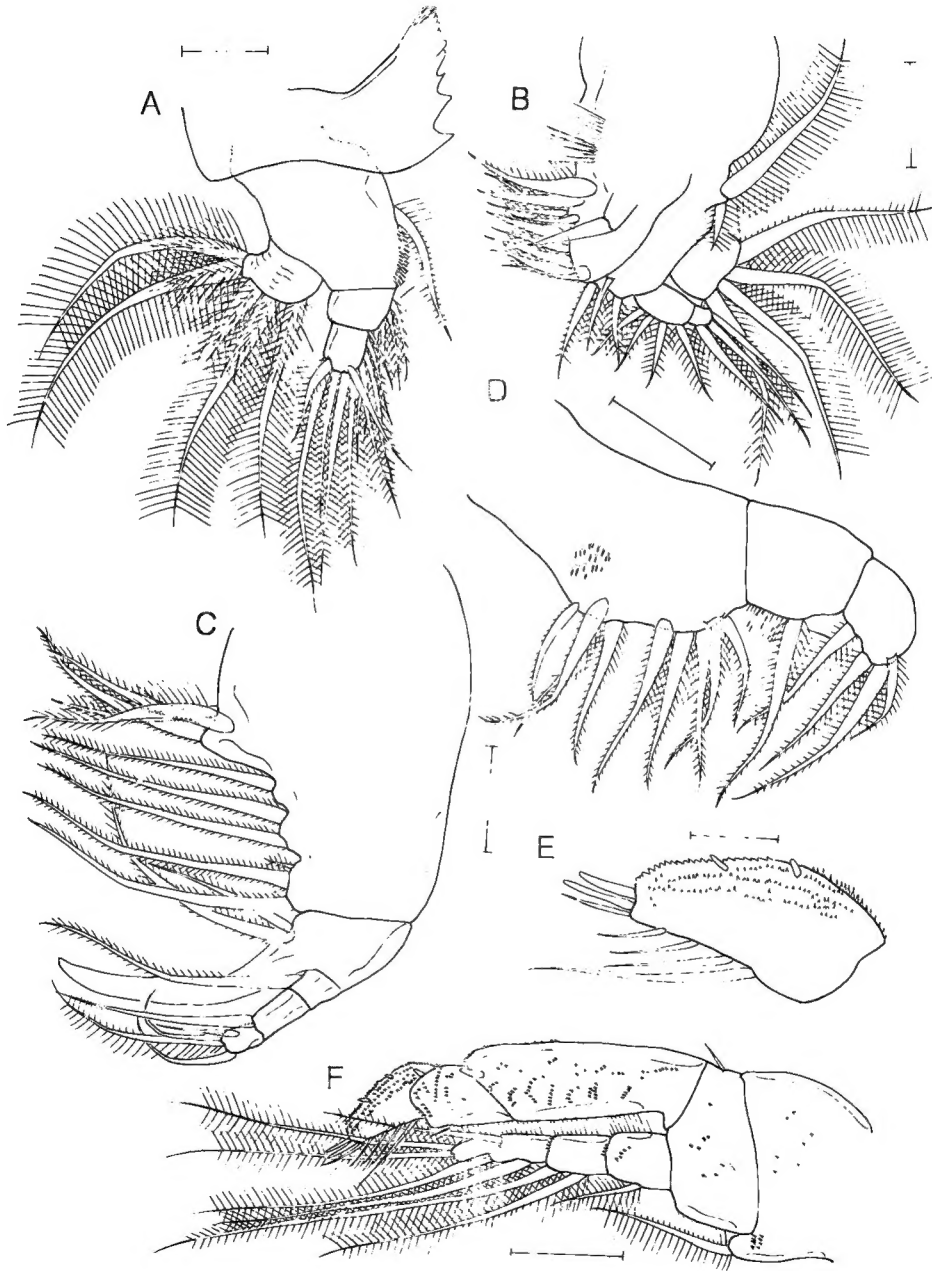


Fig. 8. *Pachypygus curvatus* Ooishi, female. A, mandible; B, maxillule; C, maxilla; D, maxilliped; E, leg 4, exopod, distal segment; F, leg 4. Scales: A - D = 0.1 mm; E, F = 0.3 mm.

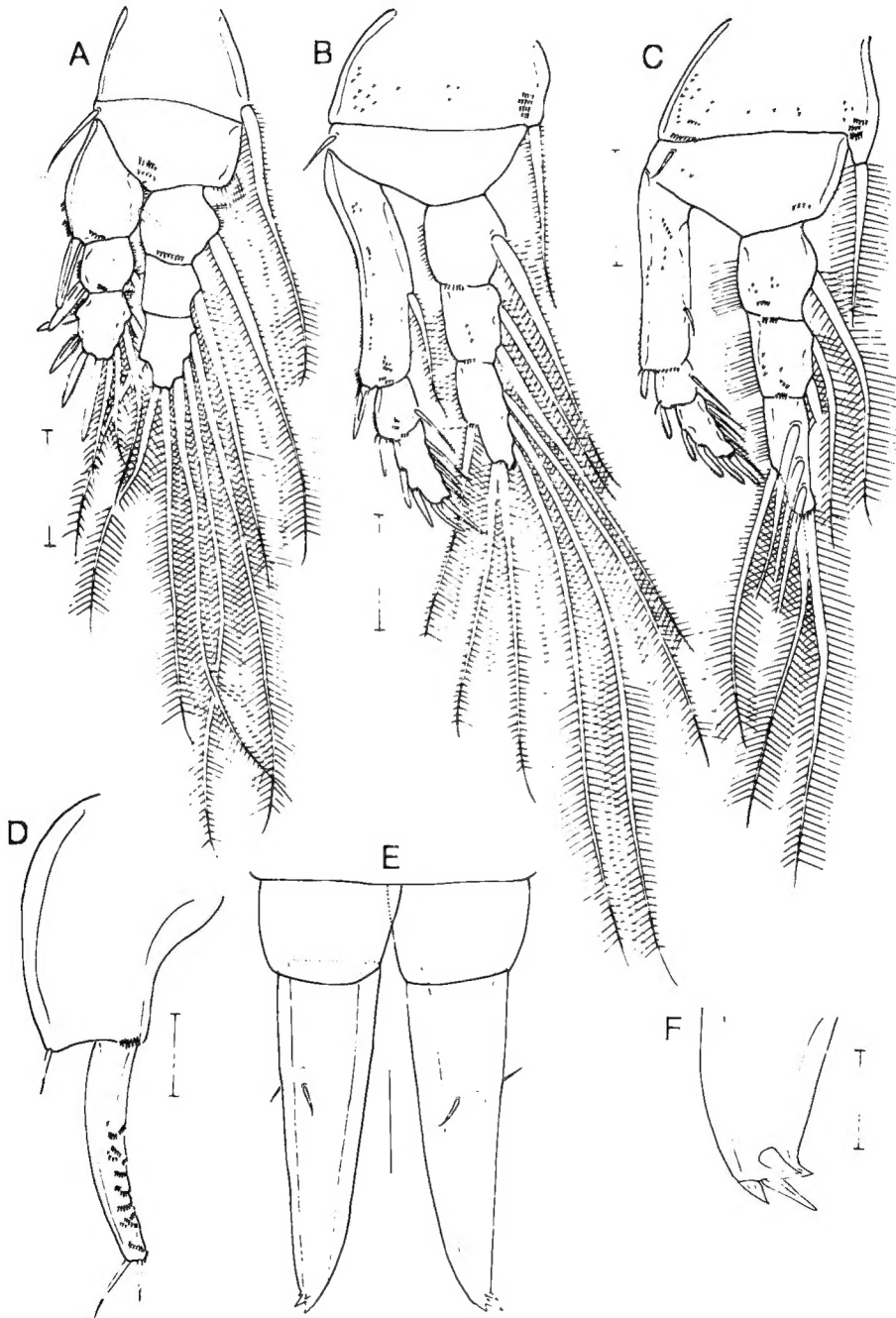


Fig. 9. *Pachypygus curvatus* Ooishi, female. A, leg 1; B, leg 2; C, leg 3; D, leg 5, right; E, anal segment and caudal rami; F, terminal portion of caudal ramus. Scales: A - C = 0.3 mm; D, E = 0.1 mm; F = 0.03 mm.